EVERYDAY LISTENING TO AUDITORY DISPLAYS: LESSONS FROM ACOUSTIC ECOLOGY

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ABSTRACT

In order to design auditory displays that function well within the cultural, informational and acoustic ecology of everyday situations designers as well as researchers in psychoacoustics need to continue to gain a better understanding of how listeners hear and make sense of information in more ecological settings and outside the lab! In this paper the authors present a preliminary study that builds on past work and theoretical ideas from acoustic ecology, exploring the practice of *everyday listening* in settings containing auditory displays. This pilot study involves 10 participants who are asked to listen to two separate soundscapes and describe in three tasks, both verbally and in writing, what they hear and how they make sense of these aural environments. The results suggest directions for understanding everyday listening form a holistic perspective in order to inform both the design of auditory displays, and the development of other research tools and instruments for measuring auditory perception ecologically. The bigger study which involves 100 participants has been completed and is expected to be published shortly as a journal article.

1. INTRODUCTION

As auditory displays become increasingly integrated within everyday products, services and environments, both designers of auditory displays and researchers of auditory perception have to continue to find better ways of understanding how these new ecologies of listening and sonic messages function together. Laboratory experiments with simple tones, while useful in establishing baseline psychoacoustic guidelines, become more and more insufficient in addressing listening as an everyday practice given the widening gap between psychoacoustic research and 'everyday' settings. As interdisciplinary research begins to become the norm rather than the exception in exploring and researching complex phenomena, the authors hereby attempt to infuse and mobilize several fields of study towards the investigation of everyday listening. In particular, we suggest that acoustic ecology offers some useful frameworks for understanding how soundscapes function ecologically and how listeners approach the reception and interpretation of sonic messages within their larger acoustic environment, including its socio-cultural context, informational and semiotic ecologies. The study we present here offers a preliminary attempt to identify salient themes, approaches and ways of mapping complex, everyday soundscapes that contain auditory displays, through both linguistic, reflective, and graphic notation systems. For this pilot study, we begin with linguistic and narrative structures and in analyzing them, help identify, categorize and develop ways of representing the various sonic, spatial and temporal elements of a given (electro)-acoustic ecology.

2. SOUNDSCAPE MAPPING – PAST RESEARCH

The need for developing multi-lateral tools for soundscape mapping in research that aims at understanding how auditory displays fit in and function within complex "everyday" environments has already been documented [1, 2]. However, initiatives to understand listening, outside of its purely perceptual and psychological characteristics, are few to find. Fewer still are examples of studies where soundscape mapping is connected explicitly with notions from acoustic ecology. We believe it is crucial, particularly in our increasingly ambient intelligent multi-sensory environments that research should aim at exploring more *ecological* notions of listening and focus on how people attend to and make sense of their everyday soundscapes. Such studies would focus on two aspects of auditory display research – firstly, on improving the ecological validity of psychoacoustic research by infusing it with frameworks and approaches such as acoustic ecology (but potentially open to cultural and critical approaches as well); and secondly, by continuing to develop soundscape mapping/research methodologies and identifying salient perceptual characteristics for the reception of auditory displays in everyday contexts.

Soundscape mapping can take the form of various graphic notation systems for logging and representing both individual sounds and entire soundscapes. It exists as a tool in several areas of research, design and community practice: classifying the elements of a soundscape – a type of comprehensive auditory ontology – through either a functional/categorical or spatially-oriented framework; visualizing soundfield measurements and sonic characteristics such as magnitude, frequency spectrum, dynamics and temporality; and finally, representing a listener's perspective of a given soundscape. Classifying sonic elements is not new – important past works include Gaver's [3] classification of everyday sounds as well as Hellström's [4] mapping schema combining spatial and structural sonic components. Organizing soundscape classifications according to perceived sound quality, aesthetic or emotional content, spatial characteristics, interactive functionality and informational significance has resulted in a

number of soundscape ontologies that remain in schematic form. Notation systems that progress to graphical representation include Coleman, Macauley and Newell's [5] sound map tool designed for participatory workshops, similar design process instruments and most notably the tools, frameworks and classifications to come from the ethnographic work of R. M. Schafer [6] and the World Soundscape Project in the late 1960s/early 70s. Schafer's approach to soundscape mapping is most unique in the ecological framework within which sound is positioned as a subject of study and as a phenomenological experience. Schafer's classification of soundscape components into prominent or significant sonic characteristics that define communities reflects a view of soundscapes as profoundly listener-centered. In other words, the significance of each sound environment, each context in which a variety of sounds exist in an "acoustic ecology" is determined and shaped by the listeners who occupy that setting. This represents a shift in soundscape mapping frameworks from ones that focus largely on the informational and functional characteristics of sounds, to ones that focus on people's listening experiences in various degrees of complexity. Again, this is critical, we think, to understanding the context in which people experience auditory displays in everyday life, both in specific situations, as we all in terms of macro trends of listening attention, information retrieval, and other associative characteristics inside a perception-cognition-action loop. Such approaches, naturally, also have predecessors. In surveying the field of what Schiewe and Kornfield [8] refer to as audio cartography, they argue that the visualization of sound has been for the most part disregarded and limited in scope. They suggest that acoustic geography should incorporate both subjective and measured dimensions in spatial terms, and that descriptions and measurements ought to be combined from soundscape research [6], acoustics [9] and psychoacoustics [10]. Their system identifies the following elements to be incorporated in soundscape mapping: sonic balance, sound events and soundmarks; sound pressure levels, intensity, trajectory and frequency of sound; perceptual parameters such as loudness, pitch, timbre, rhythm, fluctuation and annoyance. Figure 1 shows an illustration of employing these elements in a graphed sound zone, and a dynamic listener profile alongside.

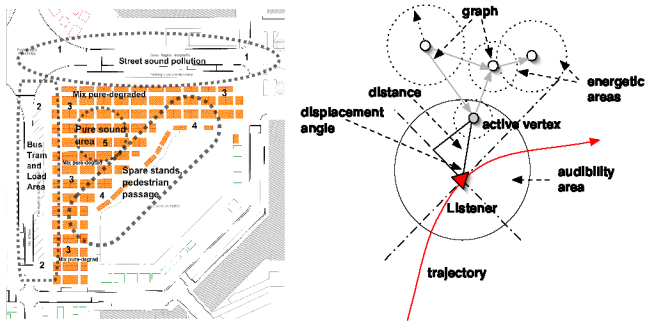

Figure 1: Map indicating sound zones and a listener profile including direction and trajectories of auditory horizon [11].

Within the category of soundscape mapping as a perceptual phenomenon, we distinguish techniques that only include listeners' experiences [7, 12, 13, 14, 15] from methods that combine both soundfield measurements and listeners' experiences [6, 8, 11, 16]. Most approaches rely predominantly on the identification and meaning of sound sources along with spatial, dynamics, temporal and spectral attributes. Most works are preliminary and often lack fully annotated examples, or simply do not provide a basis for their graphical, aesthetical and functionally representative choices for soundscape mapping. Thus one of the critical tasks scaffolding any attempt to develop a comprehensive system of soundscape mapping is a good classification system of both the soundscape's elements, as well as the relevant aspects of listening. Identifying what are important characteristics about the soundscape and about the listening experience in everyday contexts is precisely the gap that requires further exploration in order to inform both the fields of auditory display design and auditory perception research.

3. LESSONS FROM ACOUSTIC ECOLOGY

The main reason for harnessing acoustic ecology in auditory display research is of course to better understand the complexities of listening and to help develop more comprehensive tools for mapping soundscapes both in terms of how auditory displays fit in a given environment/context, and how people listen to and make sense of these augmented environments. Acoustic ecology is a field of study, research and international activism that was established through Schafer's [6] work with the World Soundscape Project (WSP). Concerns over rising urban noise levels and a commitment to preserving the participatory and communal nature of the acoustic environments are at the heart of acoustic ecology. That project – the result of several years' worth of ethnographic work mainly located around five villages in Western Europe – reveals, among other things, strong connections between the aural world, local culture and the functioning of everyday life. This is documented in numerous interviews with local residents about their soundscapes revealing a deep relationship between the aural environment and notions of place, time and self. In publications following the WSP, and with the help of the WSP team, Schafer developed a simple organizing ontology of the soundscape as containing at least three types of sounds – signals, soundmarks and keynote sounds [6]. While these sounds would be different for each 'acoustic community' (see Figure 3) depending on what sounds take on significance in the local soundscape, they would *function* in similar ways everywhere. Soundmarks in particular, termed after visual landmarks, are sounds that listeners associate strongly with their acoustic community – examples could be anything from factory steam whistles, to water streams, church bells and typical bird songs [6]. Acoustic communities are not static, however, as significant sounds become introduced in the soundscape, they change and shift in importance with time. It is the listeners and their awareness and acknowledgement of the emplacing, situational nature of sound that supplies the other ingredient of each acoustic ecology. As Truax [18] points out, extending Schafer's notions of the soundscape, the nature of acoustic communication positions the listener, the sound and the soundscape in a dynamic, two-way flow of interaction, communication and interdependence. Both our listening and our soundmaking, according to Truax, are functions of the context in which we listen and sound – not only culturally, but literally. Our ears pick up on relevant cues and properties of each (electro)-acoustic context in order to apply dimensional and associational judgments and sort of what sound events,

sound characteristics and informational aspects to tune into [18]. One simple example is the concept of acoustic *masking* – when we are in an environment, which is 'loud,' we have to respond by raising our voices in order to communicate, in essence adding to the noise. However, in a more granular aspect of that situation, one that Truax terms 'cocktail-party effect' our ears pick up on the voice of a familiar person even in the crowd and noisiness of a group event. In acoustic ecology, special importance is placed on the distinction between acoustic and electroacoustic environments. Marked by the possibility of artificial amplification, which necessarily shifts the sonic balance of natural environments, electroacoustic communication [18] entails cultural, social and economical dimensions in the way it acculturates listeners. Exposure to media soundscapes for over a century now has given rise, according to Truax, to a variety of specific listening positions that are attuned to and respond to the flow, construction and sonic parameters of media listening [18]. Yet there is a redeeming factor in the notion of an 'ecology' that resists a technological determinism that typically blames sonic imbalance on technological urban progress. In fact, Truax and Schafer would argue that even by virtue of being and acting in a soundscape, we affect it as both its listeners and its composers [6, 18].

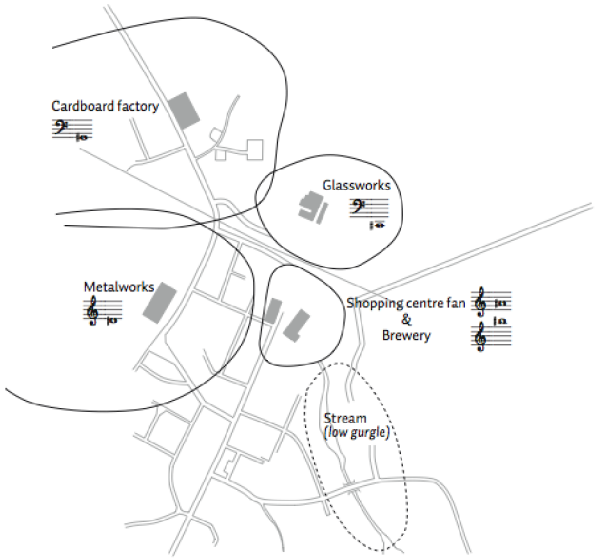

Figure 2: Diagram of the acoustic profiles of local soundmarks and keynotes from the village of Skriv, reprint from Acoustic Environments in Change/ Five Village Soundscapes [19].

The notions most important to our present project to come out of acoustic ecology involve three ideas: graphically representing – soundscape mapping – multiple listener accounts, that is to say, presenting a macro scale of soundfield information and listener data – see Figure 2 – while placing special importance on the layers of sound information, the sound profiles (audible scopes) of various elements and the way in which they constitute particular *electroacoustic communities*. The significance of this approach to auditory display research is, of course, the fact that, ecologically-speaking, there are not only multiple auditory displays in a given setting, but there are normally multiple listeners that researchers, as well as designers, rarely explore on a macro-level, thus obscuring the communal experience of hearing and interpreting auditory displays in the context of each electroacoustic community. More contemporary work at the intersection of acoustic ecology and cultural studies serves as proof that the potential of this field is yet to fully blossom [12]. Another useful notion to come out of the acoustic ecology field is a sensitivity to the temporal dimension of listening. While much of auditory perception research and auditory display design assumes that sounds are experienced fundamentally on a spatial plane in a single unit of time; and that soundscapes are place-bound [4, 13, 14] everyday listening is essentially temporal, event-related, intimately coupled with context, subjectivity and attention – which are purveyors of time as well. Space and time, therefore must both be accounted for in an ecological instrument for understanding everyday listening. For designers and researchers of auditory displays, it is not, perhaps, quite enough to understand how well listeners can spatially locate as well as functionally and informationally identify sound signals – it is also important to understand how listening shifts and how soundscapes themselves change, both ecologically and perceptually, over time. The graph in Figure 3 also comes from Five Villages, part of the WSP project [6], and reflects a graphic combination of sound level measurement with time coded, annotated sound events. Many more such hand-drawn graphics and maps can be found in the supplementary WSP materials library. Sound graphs, as well as sonic maps, are integral ways of representing a soundscape as a listening account, while being sensitive to both temporal and spatial dimensions of soundscapes and of listeners.

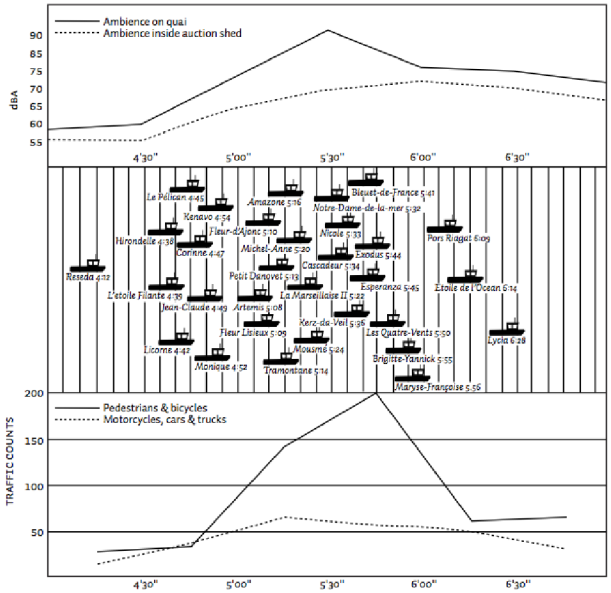

Figure 3: A temporal sound diagram reflecting the arrival of the fishing boats in Lesconil, France prior to the daily auction, as documented in Five Village Soundscapes - reprint from Acoustic Environments in Change, [19].

Finally, a method from Schafer's work that has been used in others' design work already, and which, admittedly, resembles

similar ethnographic approaches is the *earwitness account.* An interview elicited specifically with regard to a regular listener's intimate familiarity with the soundscape, in some reflective detail constitutes an earwitness account. While Schafer didn't explicitly acknowledge it, much of his background research relies on language, particularly literary accounts of historical soundscapes [6]. While language is limited in the sense that untrained listeners rarely possess a great vocabulary to describe their soundscape (Schafer imagines a long programme of ear-cleaning and re-engagement with sound to remedy that), there are still many things to be gleaned from the way listeners communicate about what they hear – and we hope to elaborate on that in this current undertaking. In addition, earwitness accounts typically rely on memory, rather than immediate stimulation with sound, with the exception of the practice of soundwalking, which aims at phenomenological authenticity in the listening experience. Yet even then, reflection on that soundscape happens after, and is therefore reflective and discerning on a meta-level. But what of using earwitness accounts on real-time listening? What could that immediate commentary reveal about the order in which things are heard, the significance of sonic events as they unfold in time and within the dynamic sense of context in the sound space. Where user-solicited open-ended graphic representations could sometimes be intimidating, language is familiar even if vocabulary is limited. Importantly, language is never meant to speak on its own, but offer a perspective in conjunction with soundfield measurements, audio recordings, expert characterizations or other materials.

There are several critical shortcomings of Schafer's soundscape classification system as well as of other derivative and related mapping frameworks around acoustic ecology [4, 7, 8]. As mentioned above, all of the methods are targeted at trained listeners who either report their own responses or interpret other listeners' experiences. Critics have also pointed out the inherent romaniticization of natural sound environments in Schafer's writings, in contrast to urban soundscapes which feature mechanical and electroacoustic sounds heavily. This has led to a normative hierarchy in the very classification Schafer uses to characterize soundscapes. While the idea of acoustic ecology is open-ended, the frameworks developed by Schafer and Truax are often presented as closed systems [6, 18]. These may perhaps be some of the reasons why formulations from acoustic ecology have had little to no uptake in other disciplines dealing with auditory perception and design of auditory displays. Yet we feel that a return to this unique way of conceptualizing soundscapes and listening is full of potential for understanding better how listeners perceive and interpret their auditory display-filled everyday soundscapes.

4. THE STUDY: MAPPING EVERYDAY LISTENING

As already mentioned, one of the major drawbacks to using soundscape mapping tools for the purposes of exploring the listener's perspective in an ecological manner is that these instruments are generally not validated, often exist only in prototype form and limited features prevent the representation of complex everyday soundscapes. Undertaking this project both authors build on prior work exploring listening that combines research with spatial-functional soundscape mapping through symbolic graphical notation [2]; as well as novel methodological approaches to categorizing and visualizing temporal patterns of listening/aural fluencies in the context of complex, ambient soundscapes [17]. Following a process of iterative validation, we present the first step towards developing a larger-scale comprehensive, ecological instrument for researching "everyday listening" in contexts where auditory displays play a formative role in the constitution of an *electroacoustic community.* Our project so far involves soliciting real-time listener commentary and reflection in a set of listening tasks performed with a small pilot group of participants. For this stage of the study, we have chosen two recorded soundscapes that both convey familiar everyday settings where auditory displays play a central part to form a unique and familiar electroacoustic community: one features the inside of a bank building near a set of ATM machines being used; and the other takes place at a grocery store line-up as a store clerk is "ringing" items on the cash register. We recruited 10 participants, all undergraduate students, and presented each of them individually with the two soundscapes, over headphones. Each soundscape was just over 2 minutes long. We asked participants to perform three listening tasks for each soundscape, which was correspondingly played three times in succession. In the first task, the participant is asked to identify and describe sounds that they hear in a *Think Aloud* protocol – a real-time earwitness account – as the recording plays. The recording is delivered through headphones and recorded in real-time in a multi-session track, while the participant's voice is recorded in a separate track at the same time. Upon their second hearing, they are asked to comment on the overall function of the soundscape, and after the recording is over, to discuss how well the soundscape reflected the intended function and context of the space/place. In the third task they are asked, after the recording plays completely, to create a written reflection in the form of an 'aural postcard' – a narrative about what happened in the recording, what was significant, and what sort of associations it evoked for them. The format of this study comes from a combination of Schafer's earwitness accounts, design workshop methods such as Think Aloud protocols, and ethnographic techniques such as narrativized accounts. The point is to get at several levels of phenomenological reflection on everyday listening as an experiential phenomenon – from more immediate to more conceptual/abstract. The role of analysis after then, becomes in extracting relevant patterns about the significance of listening practices in relation to the function of auditory displays within complex acoustic ecologies of everyday situations. Data collection includes integrated audio of the recorded soundscape and participant's oral account, transcripts of the oral accounts, and written reflections. Analysis includes a visual open-coding of the integrated audio, plus a more formalized stage of content and discourse analysis using the Atlas.ti qualitative coding environment that aims at identifying significant patterns of both everyday soundscapes and everyday listening. At that stage, we will be incorporating an inter-coder component in the study as well, to ensure date is consistent and reliable.

5. RESULTS AND DISCUSSION

Rather than focusing on number of correct identifications of sounds – an approach that would only reveal mechanical aural

perception – we instead shift our analytical focus on instances of specific listening approaches, and attempt to build salient patterns through careful examination of the three-tier accounts we have for each participant and each listening sample. Upon preliminary analysis, we were able to identify several emergent aspects related to the process of listening and nature of meaning-making in everyday soundscapes. Coding of the integrated audio in Tasks 1 and 2 for both soundscapes was done using the visual sound annotation tool *Sonic Visualizer* created by a development team at Queen Mary, University of London. Coding for the full study of 100 participants will be conducted using the qualitative software Atlas.ti in the form of discourse analysis. While the Sonic Visualizer tool automatically allows us to view significant events on a temporal scale, the multi-layer annotation feature allows us to juxtapose an expert's (researcher's) descriptions of the sonic events against commentary made by participants. Further, using the open-coding framework of this software we employed an iterative process involving several stages and levels of coding in order to refine a coding schema for participant responses that encompasses relevant dimensions of sonic comprehension. Based on our work so far we will discuss and illustrate four such dimensions of everyday listening – temporal, experiential, spatial and semiotic.

5.1. Temporal Dimension

Understanding how listeners hear, make sense of and shift listening modes as well as cognitive-attentional foci in a given setting is necessarily a complex process, and as much a function of perception as it is of time of exposure, level of engagement, familiarity and memory. Exploring the temporal dimension of listening in our present study consists of attempting to establish and uncover patterns in the way participants experience the given soundscape and make sense of the space, functionality and significance of what they are hearing. We are in essence looking for the temporal structure of everyday listening. Specifically, we look for stages in listening attentions as it shifts from background to foreground, or attends to sound events as opposed to sound qualities or spatial details. This temporal dimension exists in each individual task, however, taken together – the three tasks for each soundscape also add a dimension of increasing familiarity with a soundscape, and thus potential for greater reflectivity and interpretation.

In our preliminary analysis, we found that in the first task most participants tended to start by characterizing or contextualizing the soundscape – or attempting to do so; then they move on to identifying more foreground sounds, or background sound events, and in a few cases begin to associate how the sounds fit together and what sort of space, occasion or scenario is being presented to them. In the second task, overall, there is a greater level of interpretive elaboration, however, still switching back and forth between identifying potentially significant sound events, and articulating descriptive details about sounds that are heard. While in the first task it seems that listening attention is engaged with identification, in the second task the listening attention becomes more interpretive, reflective, while still tuning back in to the sound to confirm or check an assumption about the soundscape's functions and elements. Post-discussion after Task 2 and less so Task 3 (a written reflection) reveal even more reflective accounts, with more mention of the cognitive process that participants engaged in. We will return to this idea of temporal structure of everyday listening in the final discussion section again, tying together the lessons learned from the other relevant dimensions.

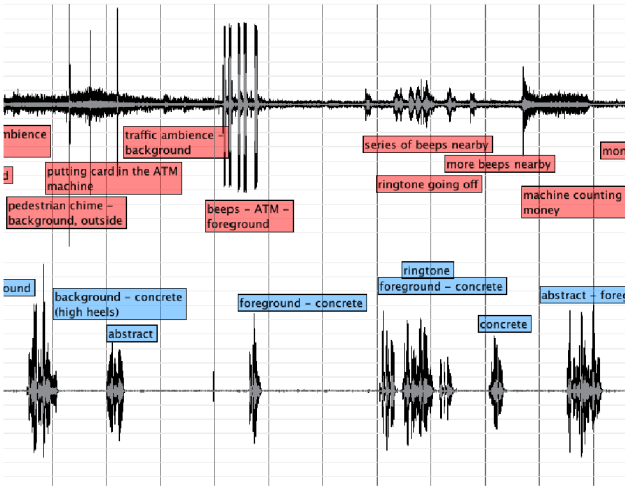

Figure 4: A zoom-in screenshot from the annotated audio transcripts from Task 1 (Soundscape1-Bank) for participant #3. Left channel – soundscape; right channel – *Think Aloud* audio; Red labels are researcher annotations of the soundscape (actual) and blue labels are coded participant comments (perceived).

5.2. Spatial Dimension

There is no doubt that sound is spatial and upon being presented with a listening task, participants are highly attuned to and responsive to the spatial and contextual characteristics of the soundscape they are hearing. This was the case in our study as well. While in the *Think Aloud* component of Tasks 1 and 2 participants often did not explicitly acknowledge whether a sound was foreground or background, in the post-discussion they relayed more detail. Again, as with the temporal dimension, the buildup of familiarity with the recorded soundscape played a central part in the attention to spatial characteristics. In Task 1, Soundscape 2 –Grocery for example, most participants correctly identified the ambience right away, even without explicitly stating how – most comments consisted of short detail about sounds in the foreground (*P9-Sounds like plastic bag noises....Canned tins and plastic noises...the products are package-based;*). Thus in Task 2 and 3, no one of the participants made specific spatial references to the soundscape – in terms of its size, configuration or depth of the various sonic signals; rather, most participants made contextual references to sounds that were familiar, which allowed them to identify the space as a grocery store and so the level of spatial observation refrained to identifying foreground versus background sounds. In other words aural comprehension shifted very quickly from contextualizing to concrete story-building of events that take place. In the Soundscape 1-Bank, most participants actually had trouble identifying the space – ideas ranged from parking lot, warehouse, factory, shop/store, office, even outside. Interestingly, in Task 2 and the post-discussion of

Task 2, many more of participants made specific and discerning references to the spatial character of the soundscape, describing in detail which aspects of the spatial character of sound led them to conclude what type of space it is: *P9 – It's a transportation station perhaps for trains or buses. Em, there's lots of echo noises around, it's a wide space, there's ongoing construction and there's um the moving metal trollies. And you can hear the echo noise, em, the long reverberation or echo noises of transport nearby.*

5.3. Semiotic Dimension

The semiotic dimension of this everyday listening exercise reflects the informational, associational and general 'sense-making' strategies that participants engaged in trying to understand the two soundscapes. Utilizing an open-coding iterative approach to participants' comments in all three tasks we devised a classification system for the way participants described and identified sounds, resulting in several more granular categories: **Sound Typologies: concrete vs. abstract** sound references; **Associational** sound identifications; and **Narrative** elaborations (see Table 1). Naturally, most often, each listening experience or instance of listening entails a combination of these approaches.

5.3.1. Sound Typologies: Concrete / Abstract identification

Concrete references involve mention of particular sonic objects, events or situations, while abstract sounds merely refer to the general sonic character or sound quality of what is heard. Concrete references by participants in Task 1 included comments such as "a beep", "woman speaking", "footsteps", while abstract references included "a shuffling", "loud noise", "high-pitched sound". The difference, essentially, is one of degree or level of identification of a sound even in a general way, as opposed to a reference only to the general idea/character of the sound in more abstract terms without necessarily specifying it. Sound events and details could be said to be a type of concrete sonic reference that go further than a concrete acknowledgement and refer to implied action or physical-interactional properties of the object. Sound events are indicated by participant comments such as "Things being dropped.", "Cages opening and closing", "Trolley being pushed...keys being pressed." Sound details include more direct references to the materials and interactions of sound such as "metal cages", "tin cans", "rustling of plastic bags", "package-based items". As mentioned above most often participant comments involved a combination of several levels of sound identification. To exemplify, we look in detail at the Task 1 transcript of Participant 6, listening to Soundscape 1-Bank: it starts with four foreground beeps, identified by the participant with a *concrete* reference; the soundscape continues with some mid-ground beeps and a very short mobile phone ring in the distance, identified by the participant as a *concrete sound event* of a Nokia phone; this is followed by the foreground sounds of an ATM accepting a card in the slot, then counting money and dispensing them – identified by the participant as the *concrete* sound "of a cash machine", accompanied by an interpretive gander at the meaning – "a ticket machine printing maybe" – as an *associational* reference. This type of meta-level coding allows us to get beyond individual reporting styles and look at more general patterns across participants in their semiotic approach auditory information in an everyday context.

5.3.1. Associational sound identification

Associational references were the most common of commentary for both soundscapes on all three tasks. Associational references entail an explicit or implied association to a familiar, past experience or sound, resulting in a cognitive synthesis between what is heard and what it 'sounds like' – a type of template-matching. The way we identify those is that most often participants will preface a reference to a sound or event by saying "It sounds like..." which is typically always followed by an interpretive statement – "It sounds like a tape being put in, a tape recorder or machine of some sort", in contrast to more direct identification such as "a beep", "a machine sound", "another beep". Associational cues are key to understanding how participants make sense of a complex, everyday soundscape semiotically, and is particularly important to the identification of auditory displays as many of them are quite similar in tonal character, thus resisting a clear 'auditory template'. Association – which entails familiarity and drawing on prior experience with similar sounds seems to be, even in our small study, overwhelmingly the main technique that participants employ in listening to these soundscapes. Both soundscapes were rich in simple auditory displays – beeps and related signals – strikingly similar in tone/duration/quality even as the contexts were completely different. Perhaps it is that generic similarity that drove participants to rely largely on associative and contextual cues. Curiously, the only two sounds that were explicitly and correctly identified by all participants were the mobile phone ring in the background of the bank soundscape, and the one error beep on the cashier till at the end of a busy transaction in the grocery store soundscape. Clearly, given that we listen for difference and adapt to similarity, it was those two out-of-place sounds that attracted attention and seemed important enough for participants to report on.

5.3.1. Narrative Elaborations

Narrative references involve a higher level of association in the form of what we'd call *imaginative listening*. While associational cues generally consist of interpretation on a single or discreet sound event, narrative references entail entire scenarios – stringing together sonic cues into a coherent story, narrating the events that are [potentially] taking place, and in that, referencing contextual details that are not in the original soundscapes. In the case of Soundscape 1-Bank, narrative accounts did not surface until the post-Task 2 discussion (*P4 [who thought this was a car park underground] - somebody's phone going off, somebody's phoning them to find out where they are of if they, you know, just parked the car, and they're just getting out of the car*). Since most participants did not correctly identify Soundscape 1-Bank, but did correctly identify Soundscape 2-Grocery, associational cues in conjunction with narrative constructions reveal a lot about the process of listeners' meaning-making. For those in Task 1 who thought the bank environment was a car park, every beep became "the sound of vehicle reversing", while the rumbling of the ATM counting money and dispensing them became "motor or

machine sounds" or "engine starting". For those who interpreted the soundscape as an office, beeps became "sounds of scanners or equipment" and the close-up ATM mechanical sounds became "a photocopier, someone pulling out paper". Participants who did more free-association on the first task and referenced a warehouse, a photocopier and a tape deck at the same space, commented on the incongruence of those sound signals in the discussion after Task 2 as they didn't quite fit into the *story* of that space. In Soundscape 2-Grocery, conversely, as early as Task 1 many participants narrated rather than identified sounds – they narrated the exchanges and almost visualized the events taking place (See some examples in Table 1.). Some participants even imagined inaudible events ("customer is probably passing off a club card of some sort"), others reported on how many tills there might be ("small shop – around 3 tills") or how many customers were present in general ("heard about 5 customers"). In the subsequent tasks for this soundscape, participants had no trouble integrating all the sounds they heard as belonging to a space that they immediately identified with a supermarket. Beeps didn't signify machinery here, but rather evoked deeply human exchanges, the "general hustle and bustle of a supermarket".

5.4. Experiential Listening

Experiential listening we'd put in its own category in order to capture instances where participants referred only to sound parameters and subjective listening characteristics such as loudness, pitch, sound colour; including their use of onomatopoeia words to identify and references sounds. While experiential listening is probably the most primary of impressions phenomenologically speaking, as far as the task sequence were concerned it tended to come up in more reflective discussions, higher level analysis, rather than in first-person narration. It seemed to be engaged more – similarly to spatial listening – when the soundscape is perceived to be more unclear, ambiguous in terms of purpose and setting.

6. SUMMARY AND DISCUSSION

What we aimed to do at this preliminary stage of the study is identify the temporal progression or structure of listening to auditory displays within everyday soundscapes that entails dynamic shifting of listening from contextualizing, to identifying, to associating, to spatially locating and interpreting sonic signals. A pattern in that temporal progression might help us understand how listening functions over time and thus *design* for it better – particularly in contexts of more ambient, multi-lateral soundscapes or in cases of more complex auditory displays. From a research perspective, this helps us identify more comprehensive tools for soundscape mapping that takes into consideration the temporal and contextual dimensions of everyday listening. In Table 1 below we synthesize the elements of soundscape perception and comprehension that has emerged from this pilot as an ontology of everyday listening for the purposes of coding and analysis of our larger study sample of 100 participants. Through an iterative process we have herby distilled useful definitions that we propose are general enough to be usable to other research explorations oriented towards the contextual and temporal nature of listening to auditory displays in ecological settings.

Spatial	Making specific references to space including proximity, size, architectural features, etc.: Inside/outside; close/far; big/small space; echo/reverb; left/right/up/down ***Example/Instances of Use:*** *P5 -I think it was either a factory or an office, but I think it was actually a bigger space than an office, or it might be a corridor in a office, but I, more I think it was actually a factory…because of all the echoes around…*
Experiential	Describing the quality of sounds as they are experienced; use of onomatopoeia words; reference to any sound parameters: Loud/quiet; timbre, pitch, rhythm, etc. ***Example/Instances of Use:*** *P4 – Very reverberant…the people's feet on the floor was quite a hard sound, like heels hitting concrete*
Semiotic	
Sound typology	**Concrete/abstract:** identifying and naming specific sounds/ identifying only general character of sounds; typically refers to sound event/action (not source). ***Example/Instances of Use:*** *P5 – Cars. Beeping of a machine. More beeping. Footsteps. Switches being pressed. More beeps. Mobile phone.*
Association	Free association based on what is heard; using associative language; limited to references to 1-2 single/individual sounds. ***Example/Instances of Use:*** *P8 – Sounds like a trolley, being wheeled around. P2 – Sounds like a bus of some sort, a vehicle taking off. And then some beeping, which could be, a vehicle reversing or something*
Narrative	Connecting several (2+) sounds together to build a story of what happened; interpreting a combination of sounds to put a sequence of events together; a higher level of associational thinking. ***Example/Instances of Use:*** *P1- Em, next customer's coming along, put their stuff through the scanner, again you can hear the beeps of the scanner…the customer just said they had a bag so I'm assuming the cashier's offered them one…Em, can hear what sounds like stuff being taken and placed into a bag, the rustling of a plastic bag*

Table 1: A schematic breakdown of the elements we identified in the temporal structure of everyday listening to complex soundscapes that feature auditory displays.

To summarize our preliminary study results, taking into account all the dimensions discussed so far, we suggest a guiding schema that reflects the listening and sense-making process that people generally follow in a soundscape listening task. As shown in Figure 5, everyday listening entails first an attention to the context, situating the listening experience; then a focusing on sound events, switching attention between foreground and background sounds and focusing on concrete identification; and ultimately associating – combining what is heard to what is known about the context and the memories of similar experiences, attempting to make coherent narrative of the experience by linking and integrating both present and associational material.

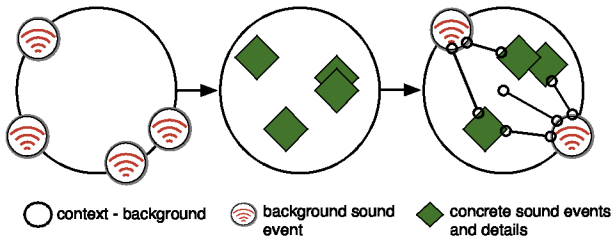

Figure 5: A conceptual model illustrating the process of listening our participants engaged in – from contextualizing sounds to identifying and interpreting them, to putting them in a coherent story.

7. CONCLUSION

To return to our initial impetus for the study - developing a research tools for exploring everyday listening that incorporates not only perceptual and functional but also ecological and contextual dimensions, there is admittedly still much work to be done. In the next stage of this analytical process, we plan to code data from the full study of 100 participants with the finalized coding schema presented here, then draw out analytical and quantitative measures towards a conceptual synthesis of listening to auditory displays in everyday settings. The full content analysis of all task transcripts should allow us to reinforce some of the conclusions proposed thus far regarding the temporal structure and sequence of listening comprehension.

The main contribution that we feel this work makes to the auditory display community is in offering a framework for incorporating acoustic ecology aspects into the validation and use of research instruments aimed at understanding and examining how people listen to auditory displays in everyday sound settings. This study puts forth a sophisticated analysis of listening in temporality bringing experiential impressions together with cognitive processes in real time. By analyzing listening modes/attentions in this way we can see what is being prioritized, what is focused on, what is lost. Even at this preliminary stage, we are able to offer a guiding structure of relevant dimensions that focus on facets of listening not typically represented in other instruments for soundscape mapping, listening task studies or field testing of auditory displays. The associational nature of listening and its importance to the contextualization, correct identification and construction of meaning with regard to auditory displays in a given soundscape is something not typically reflected in traditional perception research. Further, the lack of validated instruments for qualitative research of listening; including the use of sound maps is a gap in need of further work. It is in those areas that we situate our work and hope to make a contribution to, enriching the field of auditory displays with more interdisciplinary theory, methods and approaches. As auditory displays increasingly build into social memory and become perceptually drawn upon by listeners in everyday environments, researchers have no choice but to consider more ecological approaches to understanding perception and auditory cognition.

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